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Papers

Eradication programme for bovine viral diarrhoea virus in Orkney 2001 to 2008

I. G. R. Truysers, D. J. Mellor, R. Norquay, G. J. Gunn, K. A. Ellis

The strategies used and the results obtained in Orkney's bovine viral diarrhoea virus (BVDV) eradication programme over eight years (2001 to 2008) are presented and discussed. The venture was undertaken by local veterinary practices and the Orkney Livestock Association (OLA) with the financial support of the Orkney Islands Council. Participation is voluntary; the programme comprises screening of youngstock, a whole-herd test if required, elimination of persistently infected animals and strict biosecurity measures and/or vaccination. BVDV-free herds are certified, and certification is updated annually by retesting the youngstock. The programme aims to minimise economic losses, thereby increasing the competitiveness of the Orcadian cattle industry and to improve animal health and welfare by eliminating virus circulation. Information from databases of the Scottish Agricultural College, Biobest Laboratories and OLA show that despite a significant reduction in the overall prevalence of BVDV on Orkney during the initial stages of the eradication programme, there has been little progress made since 2006 and that some difficulties have been encountered, with herd BVDV breakdowns following initial eradication. These results highlight the need for continued motivation of farmers, strict application of biosecurity measures and/or systematic vaccination of all seronegative breeding animals.

BOVINE viral diarrhoea (BVD) is considered one of the most economically important diseases of cattle, and infections with BVD virus (BVDV) are still endemic in most cattle-producing countries throughout the world, causing significant financial losses to the industry (Houe 1999, 2003, Greiser-Wilke and others 2003, Gunn and others 2004, Lindberg and others 2006). Consequently, attempts to control or even eradicate the infection have been explored by a number of European countries (Greiser-Wilke and others 2003, Moennig and others 2005, Lindberg and others 2006). In the UK, regional eradication has been achieved in Shetland (Synge and others 1999) and is underway in Orkney, an island archipelago with the highest density of beef cows (with calf at foot) in Scotland, that is, 25 cows per km² (Scottish Government 2007), and a total number of cattle (beef and dairy) of approximately 85 cows per km² in 2008 (Scottish Government 2008). Orkney therefore has a cattle density comparable with the most dense-

ly stocked countries in Europe: Luxemburg, Belgium, Ireland and the Netherlands, with 77, 85, 95 and 96 cattle per km², respectively (World Organisation for Animal Health [OIE] 2008).

In 2001, a BVDV eradication programme, based on the Cattle Health Certification Standards (CHecsS) (www.checs.co.uk), was initiated on Orkney as a joint project between the local veterinary practices and the Orkney Livestock Association (OLA), a farmer-led organisation. The CHecsS programme evolved as an independent UK industry body and has provided guidelines for the control and eradication of BVDV, among other infectious cattle diseases, for over 10 years. The CHecsS programme in turn evolved from a cattle health assurance programme for beef and dairy farms in the Highlands and Islands of Scotland (HI-Health) and was sponsored by EC Regional funding during the previous decade. OLA, with support from the Orcadian veterinary practices, played a significant role in the development of HI-Health (Gunn and others 2001a, b).

Veterinarians and farmers agreed to tackle BVD because, in the late 1990s, before the start of the eradication programme, laboratory reports from postmortem examinations of abortions and neonatal deaths in Orkney calves by the Scottish Agricultural College (SAC) showed that 45 per cent of cases were attributed to BVDV (A. M. Clark, personal communication). The aim of this voluntary programme was to promote animal health, to eradicate BVDV among Orkney cattle herds and to increase the profitability of the local cattle industry.

This paper presents the strategies used and the course of the BVDV eradication programme to 2008 (prevalence and geographical distribution). It evaluates the efficacy of the programme and discusses why eradication is still incomplete and reinfections occur.

Materials and methods

To facilitate farmers' understanding of the status of their animals after blood testing, a colour-coding system was introduced. Antibody-negative animals (no exposure to BVDV) were colour coded as white, antibody-positive animals (exposure and seroconversion to BVDV) as

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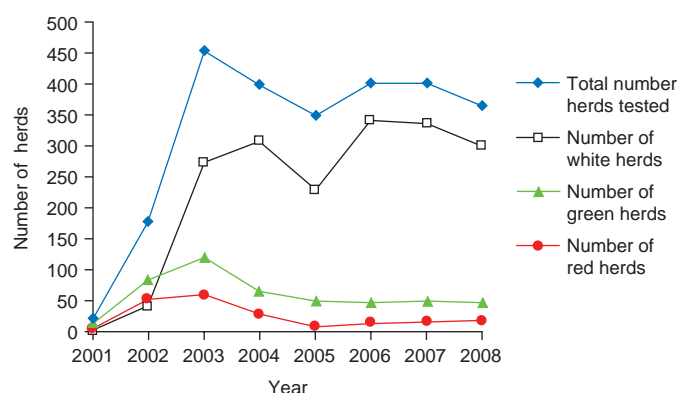


FIG 1: Number of herds tested for bovine viral diarrhoea virus (BVDV) infection and their BVDV status between 2001 and 2008 according to the colour-coding system used in the BVDV eradication programme on Orkney. White No antibodies against BVDV detected on screening: herd is considered BVDV-free. Green One or more antibody-positive animals detected on screening (and herd test), but no viraemic or persistently infected (PI) animals detected: the herd has either recently been exposed to BVDV or some of the animals tested have residual maternal antibodies. Red Viraemic or PI animals detected on screening and/or herd test: there are likely to be BVDV carriers present in the herd

green, and virus-positive animals (acutely [viraemic] or persistently infected [PI] with BVDV) as red.

Initially, 10 animals from each management group of nine- to 18-month-old stock were screened (antibody ELISA from serum) for the presence of BVDV antibodies and, based on the results of this screening, further action was undertaken. Adult animals were not included in initial antibody screening because vaccination of breeding cattle had been encouraged and animals may remain antibody positive for several years after natural infection. It was therefore impossible to demonstrate, based on screening of adult animals, whether BVDV had been active in the herd or across farm boundaries in the past year.

If, after screening of the youngstock, all animals were antibody-negative (white), it was assumed to demonstrate that there was no virus active in the herd or across boundaries during the lifetime of the animals sampled, and in this case no further testing was undertaken. Farmers were then advised to set up boundaries of no less than three metres with their neighbouring stock to prevent nose-to-nose contact over fences and walls, and/or to vaccinate all the breeding stock to prevent infection, unless they could demonstrate that all their neighbours were BVDV-free accredited. The option demonstration of accreditation of all neighbours only applied to holdings on some of the islands (Flotta, Graemsay, Gairsay, Egilsay, Wyre, North-Ronaldsay and Papa-Westray) where the total number of livestock units is very small. Only after completion of a herd health plan, which entails a veterinary inspection of the farm and livestock and on-going monitoring, evaluation of annual records of stock health, and two consecutive clear annual screening tests, could a farm be eligible for BVDV-free accreditation.

If some or all screened animals were antibody-positive (green), it demonstrated active BVDV infection within the herd or across boundaries during the lifetime of these animals, and the following actions were advised. Testing of all cattle aged more than six months on the holding was recommended to identify virus-positive animals (red). Initially, blood samples were tested by ELISA for the presence of BVDV antibodies. Where serum antibody concentrations were low (≤ 20) or 0, samples were retested by ELISA for the presence of antigen. Cattle that tested antigen-positive (red) were either retested after a minimum of three weeks to ensure they were not transiently infected, and had seroconverted, or were immediately culled from the main herd. Occasionally, cattle were reared in strict quarantine to be slaughtered at a later stage. During the first four years of Orkney's BVDV eradication programme, the Orkney Islands Council provided financial support by paying the laboratory costs for a whole-herd test if, after initial screening of the youngstock, infection with BVDV was detected.

Farmers were advised to vaccinate the antibody-negative (white) breeding stock. At the start of Orkney's BVDV eradication programme in 2001, there were two inactivated BVDV vaccines licensed in the UK. Initially, one vaccine was promoted by local veterinary practices on Orkney because it had a longer recommended period between boosters (14 months) compared to the alternative, for which revaccination was recommended every six months if all the herd is vaccinated on the same day. In 2005, an additional vaccine was launched, which required a single annual booster. However, in 2005, a vaccinated dam in a BVDV-free accredited herd was found to have produced a PI calf due to failure of the recommended vaccine following a breach in biosecurity, and similar problems were detected on other farms. As a result of this vaccine breakdown, it was decided to discontinue the use of the vaccine initially recommended on Orkney and to encourage use of the two alternatives. Antibody-positive (green) breeding stock did not require vaccination as they were considered naturally immune, but attention was drawn to the fact that they could still have a PI calf at foot or in utero. Therefore, an annual screening test of each new batch of yearlings was recommended to monitor the situation and to ensure BVDV had not entered the herd.

Other fundamental rules of the programme included isolation (three weeks quarantine) and testing of bought-in stock (including calves from imported, pregnant, antibody-positive animals); cleaning and disinfection of shared machinery, equipment, livestock trailers and handling facilities after use; and restriction of visitors and application of good general biosecurity measures at all times. The BVDV eradication programme on Orkney is open equally to members of both the dairy and beef industry, and the same rules apply for herds of both production types. Within the programme, tests were initially carried out only on blood samples. However, in 2007, the use of ear-notch testing was introduced, in order to test calves aged less than six months from imported, antibody-positive dams and in the face of a BVDV breakdown. Before ear-notch testing became available, farmers were advised, if possible, to take blood samples from such calves before ingestion of colostrum. Milk samples are not used in the interpretation of BVDV status of dairy herds on Orkney, as vaccination against BVDV is encouraged and differentiation between vaccinated and infected herds is currently not possible.

For the first four years of the scheme, the samples were analysed by veterinary surgeons at SAC Veterinary Science Division using an indirect BVD antibody ELISA (Svanova) and a double mAb ELISA (Svanova) for the detection of viral antigen in peripheral blood leucocytes. The latter test was replaced towards the end of 2002 by a BVD antigen ELISA (IDEXX) that detects E^{ms} antigen (a glycoprotein of the virus). Since February 2005, Biobest Laboratories, has undertaken the laboratory testing. Biobest uses its own validated indirect BVD antibody ELISA (validated against the reference serum neutralisation test and from study samples of known BVDV status) and the BVD antigen ELISA based on the detection of E^{ms} antigen. The results of this study are based on information obtained from databases of both the SAC and Biobest Laboratories and the OLA. Interpretation of analyses was informed by extensive personal communication with local veterinarians and members of OLA. The spatial and temporal changes in BVDV prevalence on Orkney were analysed using standard data analysis techniques available in proprietary database and geographical information system (GIS) computer software. For the purposes of data presentation and mapping, Orkney was divided into 25 geographical areas, on the basis of parish and island boundaries.

Results

At the start of the BVDV eradication programme in 2001, there were 42 dairy and 580 beef suckler holdings registered on Orkney (Scottish Government 2001), although it was thought that only 31 herds were still actively engaged in dairy farming at the time. These numbers decreased to 28 dairy (33 per cent decrease) and 509 beef suckler (12 per cent decrease) holdings in 2008 (Scottish Government 2008). In an area of slightly less than 1000 km², there were approximately 93,000 cattle in 2001, of which more than 32,000 were cows, most of them beef-suckler cows, with approximately 3500 dairy cows

TABLE 1: Numbers of blood samples tested for bovine viral diarrhoea virus antibody and antigen from cattle on Orkney between 2001 and 2008, according to data from Scottish Agricultural College and Biobest Laboratories

	Year								
	2001	2002	2003	2004	2005	2006	2007	2008	Total
Antibody tests	2315	13999	13553	7404	2925	4959	5936	5606	56697
Antibody-negative	505	3484	5722	4256	2553	3899	4171	4085	28675
Antibody-positive	1810	10515	7831	3134	372	1060	1765	1521	28008
Clotted samples	0	0	0	14	0	0	0	0	14
Antigen tests	181	1894	1432	297	127	368	530	596	5425
Antigen-negative	142	1758	1270	232	116	337	462	518	4835
Antigen-positive	37	136	162	65	9	29	68	78	584
Samples without buffy coat	0	0	0	0	0	1	0	0	1
Antigen-inconclusive results	2	0	0	0	2	1	0	0	5
Viraemic animals*	0	0	1	0	0	0	1	1	3
Confirmed persistently infected†	0	0	0	6	1	5	1	26	39
Assumed persistently infected‡	37	136	161	53	7	19	65	25	503

* Antibody-negative and antigen-positive at first sampling; antibody-positive and antigen-negative when resampled after a minimum interval of three weeks

† Antibody-negative and antigen-positive result for two samples taken a minimum of three weeks apart

‡ Antibody-negative and antigen-positive test result; no second sample was taken

(Scottish Government 2001). In 2008, these numbers had reduced to just over 85,000 cattle in total, including approximately 2500 dairy and 26,500 beef-suckler cows (Scottish Government 2008). Relatively few cattle are imported on to Orkney; however, in most herds bulls are purchased, which can be a potential source of infection in a 'closed' herd, and dairy farmers occasionally bring in-calf females on to the islands.

From the available data, it was established that 553 different holdings participated in the BVDV eradication programme between 2001 and 2008. Although participation in the programme is voluntary, and farmers have to bear the annual costs of OLA membership fees, veterinary fees and laboratory costs of screening, there were only 13 holdings remaining that had not joined the OLA following the eight-year study period (K. Tait, OLA, personal communication). Unfortunately, however, not every herd that joined the OLA undertook annual testing (Fig 1).

The total number of herds that carried out testing in 2005 (350 herds) is significantly higher than the sum of the number of white, green and red herds (285) in 2005. This discrepancy is attributable to the changeover at the start of February 2005 between the two laboratories responsible for BVDV testing as part of the eradication programme, which resulted in a significant number of test results for the first months of 2005 being incomplete or absent.

The data available for the first eight years of Orkney's BVDV eradication programme include results for a total of 56,697 samples submitted for BVDV antibody testing by ELISA: 28,675 samples tested antibody negative, 28,008 samples tested antibody positive and 14 samples were clotted and could therefore not be tested. A total of 5425 samples were also tested for viral antigen; of these, 4835 tested antigen-negative, 584 were antigen-positive, five were inconclusive and one sample could not be tested as no buffy coat was present. The 584 antigen-positive samples included initial samples from three animals that subsequently tested antigen-negative and antibody-positive when resampled after a minimum interval of three weeks. These animals were therefore considered to be acutely infected at the time of first sampling and had seroconverted when retested. It also included the results of two tests from 39 animals for which persistent infection was confirmed with a second blood sample, whereas for 503 animals, persistent infection with BVDV was assumed based on the results of only one sample. The decision to not retest these animals was often made in consultation between the veterinary surgeon and farmer and was based on clinical signs of illthrift or a history that was highly suggestive of persistent infection with BVDV (Table 1).

By 2008, 24 members had withdrawn their OLA membership (although some still continued testing for BVDV privately) and two had to be removed from participation in the programme because of non-payment of fees. Another 59 members were no longer trading. Over 80 per cent of the active members in 2008 were BVDV-free

accredited (K. Tait, OLA, personal communication), with some claiming an increase in profits of 30 per cent due to elimination of the disease. Higher productivity and reduced costs, particularly due to diminished medicine usage and veterinary services, are reported to be responsible for such changes. Mainland buyers of store cattle and breeding heifers are also prepared to pay a premium for healthy Orkney cattle.

Unfortunately, since the start of the eradication programme, 41 herds tested by annual screening, which had two or more consecutive clear tests and were therefore eligible for accreditation or were already BVDV-free accredited, suffered a BVDV breakdown. It has been officially verified by a veterinary consultant, commissioned by the vaccine manufacturer, that one of these breakdowns was caused by failure of the BVDV vaccine initially promoted by veterinarians on Orkney. This occurred in

the face of challenge by BVDV despite correct vaccine administration. The remaining breakdowns were attributed to many factors, which included not vaccinating, incorrect use of the vaccine and breaches in biosecurity (PI animals in neighbouring fields, purchased animals that were not tested or isolated properly, purchased pregnant animals carrying PI fetuses, PI animals bought or kept as 'natural vaccinators') (K. Tait, OLA, personal communication). Work investigating the sources of these breakdowns is ongoing.

The prevalence and geographical distribution of the number of white, green and red herds across the islands for the first eight years of the BVDV eradication programme on Orkney are shown in Fig 2. This figure indicates that a significant reduction in the prevalence of red herds occurred up to 2005, with some islands in particular showing dramatic changes in prevalence. However, since 2006, there has been a slight increase in the prevalence of red herds not only on mainland Orkney but also on four of the outlying islands.

Discussion

Although the prevalence of BVDV-infected herds on Orkney has significantly reduced since the start of the programme, eradication is still not complete and reinfections occur. During the initial stage of the eradication programme, good progress was achieved; however, since 2006, the prevalence of BVDV on Orkney has showed little change. As participation is voluntary, efforts have to be made to further inform and educate farmers on the background and consequences of BVDV infections to the herd. Presentation of economic analyses should help to motivate more farmers to participate and preserve the motivation of existing members to continue testing and following strict biosecurity measures to achieve and maintain BVDV-free status. At the start of the eradication programme, a series of meetings were organised by OLA and the veterinary practices; these meetings introduced the colour-coding system for BVDV infection, which was a significant step in the explanation of a difficult concept. In 2009, the course of Orkney's BVDV eradication programme up to 2008, including the results and conclusions presented in this paper, were also discussed at several farmers' meetings. Further investigation of the reported animal health and economic benefits of the BVDV eradication programme on Orkney are ongoing.

The reduction in total number of herds tested for BVDV in 2005 can partially be explained by the fact that the financial support for the laboratory costs of whole herd tests by the Orkney Islands Council finished at the end of January 2005. Additionally, the transition from SAC to Biobest Laboratories in February 2005 potentially caused a certain level of apprehension that could therefore also be associated with this reduction. From the 350 herds that were tested in 2005, only 285 results were available. Efforts to retrieve the data from OLA, SAC and Biobest were unsuccessful, and in reality retrospective interrogation of the different databases proved difficult. It is important to note that for future eradication programmes in the UK and elsewhere, strong

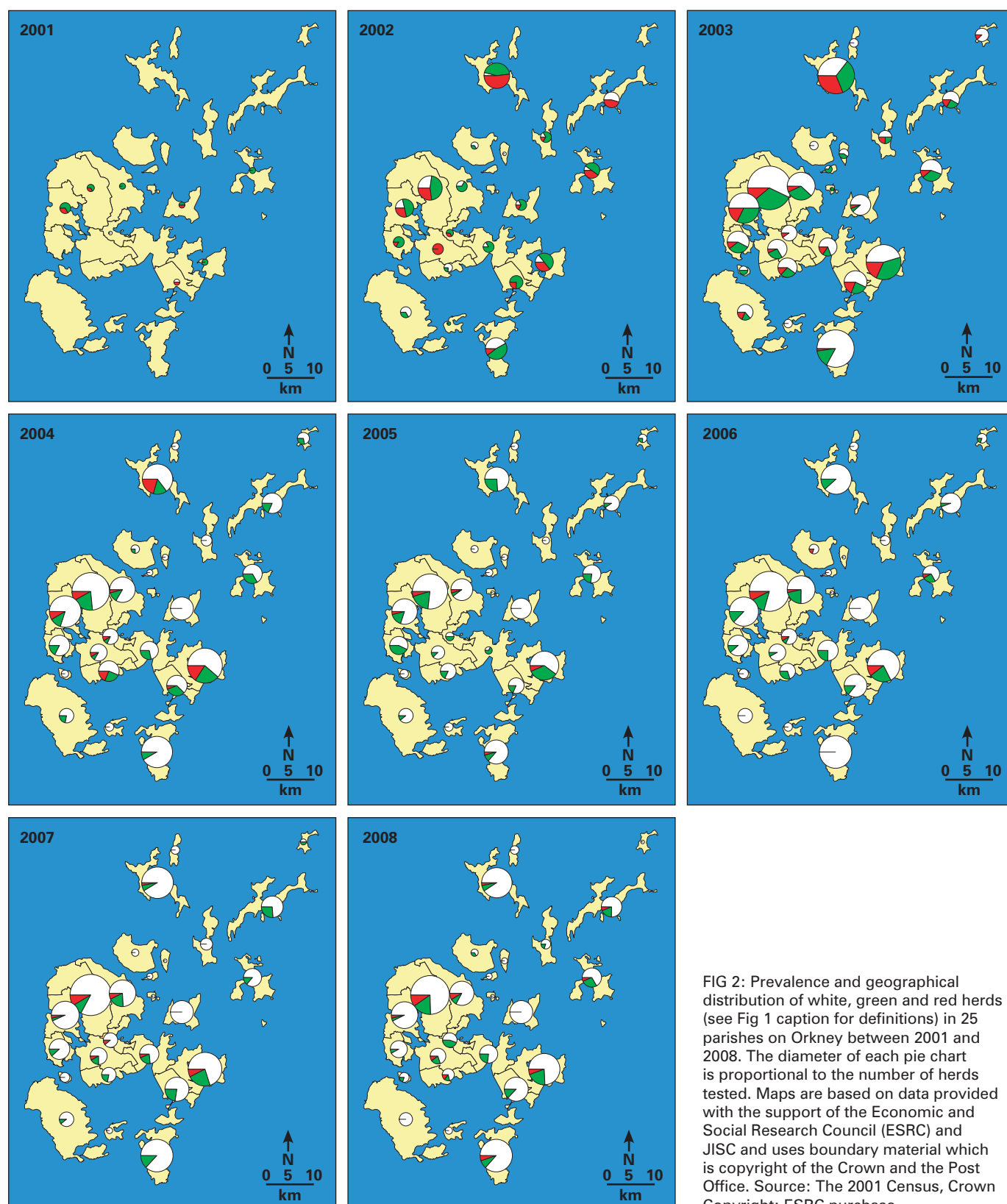


FIG 2: Prevalence and geographical distribution of white, green and red herds (see Fig 1 caption for definitions) in 25 parishes on Orkney between 2001 and 2008. The diameter of each pie chart is proportional to the number of herds tested. Maps are based on data provided with the support of the Economic and Social Research Council (ESRC) and JISC and uses boundary material which is copyright of the Crown and the Post Office. Source: The 2001 Census, Crown Copyright; ESRC purchase

consideration of and a decision on where data will be stored is vital to avoid discrepancy in results.

High cattle density and the presence of very few natural boundaries on each of the islands meant that strict biosecurity aimed at preventing reintroduction of BVDV in accredited-free herds played a key role in the eradication of the disease. In particular, the isolation and blood testing of bought-in stock have proven effective weapons against BVDV. Double-fencing boundaries with a three metre gap to prevent contact with neighbouring cattle are specified in programme guidelines, although it is not known precisely how

many farms utilised this measure. Additionally, these biosecurity measures were an aid in the prevention of other infectious pathogens. The three-week isolation period provides an opportunity to monitor purchased cattle for signs of ill health that can be caused by a number of different diseases and the three metre boundary fencing reduces the risk of disease spread between herds in general. Testing of blood samples for BVDV from bought-in stock also provides the opportunity to encourage farmers, where appropriate, to test the samples for the presence of antibodies against infectious bovine rhinotracheitis, leptospirosis and Johne's disease, thereby contributing

to the benefit of the wider health status of cattle on Orkney. From the 41 herds that suffered a BVDV breakdown on Orkney between 2001 and 2008, the number attributable to the lack of isolation and blood testing of bought-in stock, or the absence of a three metre gap between herds, is unknown but estimated to be high. Further work is needed to investigate sources of herd breakdowns. However, due to the complex nature of the disease, retrospective investigations can be difficult.

Systematic vaccination of all antibody-negative breeding cattle is strongly recommended in herds that have been cleared of viraemic and PI animals to avoid further economic losses due to BVDV-induced reproductive failure in susceptible cattle, to reduce immunosuppression, and to inhibit the emergence of new PI calves as sources of new infection on Orkney. This should be emphasised, particularly in areas where vaccine uptake has been disappointing and/or breakdowns have already occurred. Vaccination should be continued until it is feasible to maintain the virus-free status on Orkney without the use of vaccines. Unless legal support becomes available to create a framework in which disease control measures can be enforced (including preventing movement of PI animals and trade in PI animals and dams carrying PI fetuses, immediate elimination of PI animals, and obligation to inform all interested parties of and clear infection from infected herds), protection of BVDV-free herds is likely to be only achievable by a combination of strict biosecurity and consistent vaccination in certain areas in Orkney with high cattle density.

In the UK, only killed BVDV vaccines are licensed (Moennig and others 2005, Lindberg and others 2006). When the eradication programme began in Orkney, only two BVDV vaccines were available and a third was launched in 2005. Of the two original vaccines, one achieved a much greater uptake by Orkney veterinarians and farmers due to the longer recommended period between boosters. However, their confidence in this vaccine was undermined when a BVDV-free accredited farm, applying good biosecurity practices, which had been vaccinating cattle for several years following the manufacturer's instructions, suffered a BVD breakdown. Antigenic variation between the vaccine strain(s) and field strains, or inability of the vaccine to fully prevent transplacental infections, have been suggested as possible explanations for the failure of this vaccine.

Considering this, it is essential that only those BVDV vaccines that induce the broadest and most enduring fetal protection possible are used in the field. It has to be emphasised that biosecurity measures can never be allocated second place as they are fundamental in any attempt to eradicate BVDV, and that widespread BVDV vaccination as a stand-alone measure has so far failed to improve the epidemiological situation in areas it has been applied (Moennig and others 2005).

The lack of compulsory regulations for BVDV control makes voluntary control efforts subject to farmer compliance and the constant risk that cleared herds will become reinfected, thus adding the risk of excessive and unnecessary costs to farmers. Only when the emergence of new PI cattle is prevented with a high degree of certainty does the programme have a chance of complete success. National and regional approaches to BVDV eradication are at various stages in mainland Europe. In the Shetland Isles, a scheme to blood test all cattle and cull animals persistently shedding virus was initiated in 1994. In 1997 the scheme ceased because it appeared that there were no more PI animals present. Since then all bought-in cattle to Shetland and calves born to bought-in female stock are sampled and tested for BVDV antibody and virus, and close veterinary surveillance is in place (Synge and others 1999). Scandinavian countries have eradicated the virus using programmes aimed at eradication without employing vaccines. These programmes were initially voluntary but had to become compulsory before eradication was achieved. It has taken these countries approximately 10 years to reach the final phase of eradication or even achieve their goal of freedom from BVDV, and their experiences have shown that legislative support is needed in this final phase (Bitsch and others 2005, Hult and Lindberg 2005, Moennig and others 2005, Lindberg and others 2006). This shows that, as with disease control efforts in general, strategies can, and should, be revised and amended over

time if necessary, and that even when eradication programmes are not optimally designed from the start – given they are implemented in a systematic manner and with basic biosecurity, elimination of virus from infected herds and monitoring of non-infected herds – BVDV eradication is possible and profitable (Hult and Lindberg 2005).

At the end of 2005, Scotland's livestock representatives agreed a common, industry-wide cattle health declaration form aimed at improving the consistency of information provided to buyers. The Scottish Standard Cattle Health Declaration, which was launched in February 2006, helps buyers assess the relative risk of buying individual animals at sales by providing specific disease-related information and thus contributes to safeguarding livestock health. The cattle health declarations are endorsed by both farmers and veterinarians and allows breeding animals of known BVDV-status to be traded by auction. The first consignment of tested BVDV-free and vaccinated breeding females and cows with calf at foot took place in mainland Scotland in September 2009. Options for national BVD control and eradication in Scotland are currently at the centre of discussions between the different stakeholders. An outline of the options for a national approach to control the disease and of the different testing methods has been assessed, but no formal decisions have been made to date.

The impact of the BVDV-free status of regions and nations on international trade is not yet clear and would need to be reassessed (Moennig and others 2005). Currently, eight European States have acknowledged BVD in their legislation by making it a notifiable disease: Austria, Belgium, Denmark, Finland, Germany, Norway, Sweden and Switzerland. In addition, transnational regulations may be introduced as a result of the OIE listing BVDV as a priority disease in animal trade (Lindberg and others 2006).

The present study shows the considerable progress towards the eradication of BVDV on Orkney between 2001 and 2008. However, it highlights the not inconceivable technical and logistical difficulties that make final eradication hard to achieve. The lessons learned on Orkney should be noted for any future disease eradication programmes and policies in the UK and other cattle-producing countries.

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